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AUTHOR Applegate, Brooks
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ABSTRACT

Computer programs are presented to plot item and test characteristic curves and item information functions for parameter estimates produced by the LOGIST and BICAL computer programs. These programs provide data in tabular format, but their usefulness in test development and measurement courses can be greatly enhanced by graphic plots of the item and test curve characteristics. Visual inspection of the curves can facilitate item selection in test development and can improve student learning and retention of item response theory. Four programs are presented with sample curves. (SLD)

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Creating Item Characteristic Curves from LOGIST and BICAL Output

Brooks Applegate

University of Alabama

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TM 011 077

Paper presented at the Mid-South Educational Research Association annual meeting, Mobile, Alabama, November, 1987.

Creating Item Characteristic Curves

from LOGIST and BICAL Output

The discussion, explanation, and use of Item Response Theory (IRT) measurement models in test development and advanced measurement courses can be greatly aided by using commercial computer programs such as LOGIST and/or BICAL. LOGIST estimates one, two, or three parameter logistic models, while BICAL is specifically designed to perform a one parameter Rasch item calibration. These two programs produce rather lengthy outputs from which the user must sort through multiple tables for the desired information.

The purpose of this paper is not to discuss IRT or to highlight differences in LOGIST and BICAL, but to provide the user with a series of computer programs that plot item and test characteristic curves (ICCs) and item information functions for the parameter estimates produced by these programs. LOGIST and BICAL unfortunately do not generate ICCs for the item parameter estimates, but provide the necessary data in tabular format. While test developers and students are quite capable of understanding tabular data, the usefulness of IRT in test development and measurement courses can be greatly enhanced by graphic plots of the ICCs.

Several programs will be illustrated and explained that use the output generated from a LOGIST or BICAL run and plot the individual item characteristic curves for visual study. For users who do not have access to the SAS System and SAS Graph, much of the data handling and data conditioning can be performed by other computer languages such as Fortran, C, Pascal or BASIC. The output from these programs can be passed into virtually any graphics package such as DISSPLA or SPSS Graphics for subsequent plotting.

The visual inspection of ICCs can greatly facilitate item selection in test development and student understanding of IRT as well as increase the overall

usefulness of these two commercial programs. For the test developer, plot axes can be fixed so that several ICCs can be overlaid for visual comparison of the differences in item parameter estimates. Or, the ICC produced from a BICAL run can be plotted against the perfect Rasch item, highlighting differences in fit. When teaching IRT to graduate students providing individual or overlaid ICCs can greatly enhance student learning and retention. Students get a visual picture of the item parameters and their effect on an examinee's ability estimate.

RERERENCES

Hambleton, R.K. (1985). Item response theory principles and applications. Boston: Kluwer Nijhoff Publishing.

Warm, T.A. (1978). A primer of item response theory. Report No. 940279), Oklahoma, OK: U.S. Coast Guard Institute.

ESTIMATES OF THE STANDARD ERROR OF THE MAXIMUM LIKELIHOOD ESTIMATES

NOTE: PARAMETER ESTIMATES PRODUCED BY LOGIST ARE APPROXIMATIONS OF THE MAXIMUM LIKELIHOOD ESTIMATES

	ITEM NO	A STATUS	A	A STD ERR	B STATUS	B	B STD ERR	C STATUS	C	C STD ERR	PARAM CODE	B-2/A	NO OMITS	NO REACHED	P	NO CHOICES	EXTRP GROUP
1	1		0.59679	(0.365)		0.26856	(0.653)	COMC	0.06975	(0.225)	22	-3.08*	1	49	0.4745	4	0
2	2		0.67950	(0.377)		0.32723	(0.520)	COMC	0.06975	(0.187)	22	-2.62*	1	49	0.4541	4	0
3	3		1.96280	1.034		0.25381	0.219		0.19182	0.127	43	-0.77	0	49	0.5102	4	0
4	4		1.77068	0.765		0.05458	0.203		0.10942	0.122	43	-1.07	0	49	0.5306	4	0
5	5		0.86852	(0.408)		-0.02958	(0.393)	COMC	0.06975	(0.164)	22	-2.33*	0	49	0.5306	4	0
6	6	MAX	2.00000	(1.115)		0.21184	(0.234)		0.23994	(0.137)	43	-0.79	0	49	0.5510	4	0
7	7	MAX	2.00000	(1.532)		0.80376	(0.371)		0.45118	(0.111)	43	-0.20	0	49	0.5714	4	0
8	8		0.71962	(0.375)		-0.30012	(0.580)	COMC	0.06975	(0.222)	22	-3.08*	0	49	0.5918	4	0
9	9		0.92437	(0.425)		-0.26163	(0.392)	COMC	0.06975	(0.170)	22	-2.43*	0	49	0.5918	4	0
10	10		0.51382	(0.351)		-0.25873	(1.074)	COMC	0.06975	(0.341)	22	-4.15*	0	49	0.5714	4	0
11	11		0.41556	(0.359)		-0.44911	(1.904)	COMC	0.06975	(0.524)	22	-5.26*	0	49	0.5918	4	0
12	12		0.91920	(0.424)		-0.26752	(0.396)	COMC	0.06975	(0.171)	22	-2.44*	0	49	0.5918	4	0
13	13	<.3	0.29095	(0.414)		-0.59839	(5.117)	COMC	0.06975	(1.074)	22	-7.47*	0	49	0.5918	4	0
14	14		0.42169	(0.358)		-0.73521	(2.091)	COMC	0.06975	(0.581)	22	-5.48*	0	49	0.6327	4	0
15	15		0.65078	(0.365)		-0.63140	(0.808)	COMC	0.06975	(0.289)	22	-3.70*	0	49	0.6531	4	0
16	16		0.78469	(0.397)		-0.75601	(0.641)	COMC	0.06975	(0.248)	22	-3.30*	0	49	0.6939	4	0
17	17		0.60318	(0.360)		-0.89059	(1.056)	COMC	0.06975	(0.362)	22	-4.21*	0	49	0.6939	4	0
18	18		1.71829	(1.313)		0.27033	(0.406)	MAX	0.50000	(0.158)	43	-0.89	0	49	0.7143	4	0
19	19		0.69940	(0.380)		-0.99738	(0.868)	COMC	0.06975	(0.317)	22	-3.86*	0	48	0.7292	4	0
20	20		0.89227	(0.436)		-0.95824	(0.606)	COMC	0.06975	(0.241)	22	-3.20*	0	48	0.7500	4	0
21	21	<.3	0.18549	(0.634)		-4.15072	(48.969)	COMC	0.06975	(8.054)	22	-14.93*	1	47	0.7926	4	0

NOTE: '( )' INDICATES THAT ONE OR MORE OF THE PARAMETERS WERE HELD FIXED DURING THE ESTIMATION PROCEDURE AND THE STANDARD ERRORS WERE COMPUTED FOR ALL THREE PARAMETERS.

'*' INDICATES THAT B-2/A IS LESS THAN THE CRITERION FOR FIXING C AT COMC AT THE END OF THE RUN.
THE CRITERION IS -2.000000

1	0.59679	0.26856	0.06975
2	0.67950	0.32723	0.06975
3	1.96280	0.25381	0.19182
4	1.77068	0.05458	0.10942
5	0.86852	-0.02958	0.06975
6	2.00000	0.21184	0.23994
7	2.00000	0.80376	0.45118
8	0.71962	-0.30012	0.06975
9	0.92437	-0.26263	0.06975
10	0.51382	-0.25873	0.06975
11	0.41556	-0.44911	0.06975
12	0.91920	-0.26752	0.06975
13	0.29095	-0.59839	0.06975
14	0.42169	-0.73521	0.06975
15	0.65078	-0.63140	0.06975
16	0.78469	-0.75601	0.06975
17	0.60318	-0.89059	0.06975
18	1.71829	0.27033	0.50000
19	0.69940	-0.99738	0.06975
20	0.89227	-0.95824	0.06975
21	0.18549	-4.15072	0.06975

SERIAL ORDER						DIFFICULTY ORDER						FIT ORDER							
SEQ NUM	ITEM NAME	ITEM DIFF	STD ERROR	DISC INDX	FIT TTEST		SEQ NUM	ITEM NAME	ITEM DIFF	DISC INDX	FIT TTEST		SEQ NUM	ITEM NAME	ITEM DIFF	ERR IMPAC	FIT DELWN	T-TESTS TOTAL	WTD MNSQ	MNSQ SD	DISC INDX	POINT BISER
4	IT04	-4.85	0.85	1.12	0.40	!	7	IT07	-5.71	1.12	0.21	!	8	IT08	-2.88	0.00	-0.28	-1.78	0.45	0.37	1.17	0.76
5	IT05	-4.24	0.76	1.12	0.78	!	4	IT04	-4.85	1.12	0.40	!	13	IT13	2.35	0.00	-0.04	-0.64	0.79	0.31	1.19	0.59
6	IT06	-4.24	0.76	1.12	0.56	!	6	IT06	-4.24	1.12	0.56	!	9	IT09	-3.74	0.00	-0.82	-0.62	0.74	0.38	1.13	0.61
7	IT07	-5.71	1.09	1.12	0.21	!	5	IT05	-4.24	1.12	0.78	!	7	IT07	-5.71	0.00	-1.50	0.21	0.91	0.92	1.12	0.41
8	IT08	-2.88	0.65	1.17	-1.78	!	9	IT09	-3.74	1.13	-0.62	!	16	IT16	5.28	0.00	-1.53	0.28	0.98	0.91	1.13	0.33
9	IT09	-3.74	0.71	1.13	-0.62	!	8	IT08	-2.88	1.17	-1.78	!	17	IT17	5.28	0.00	-1.53	0.28	0.98	0.91	1.13	0.33
10	IT10	-1.48	0.57	0.91	1.19	!	10	IT10	-1.48	0.91	1.19	!	15	IT15	5.28	0.00	-1.53	0.28	0.98	0.91	1.13	0.33
11	IT11	1.51	0.53	1.03	0.48	!	11	IT11	1.51	1.03	0.48	!	4	IT04	-4.85	0.06	-1.24	0.40	1.12	0.55	1.12	0.40
12	IT12	3.01	0.62	0.97	0.58	!	13	IT13	2.35	1.19	-0.64	!	11	IT11	1.51	0.05	-1.06	0.48	1.11	0.28	1.03	0.58
13	IT13	2.35	0.57	1.19	-0.64	!	12	IT12	3.01	0.97	0.58	!	6	IT06	-4.24	0.09	-1.03	0.56	1.18	0.42	1.12	0.47
14	IT14	4.44	0.84	1.13	1.04	!	14	IT14	4.44	1.13	1.04	!	12	IT12	3.01	0.08	-0.07	0.58	1.18	0.36	0.97	0.42
15	IT15	5.28	1.09	1.13	0.28	!	15	IT15	5.28	1.13	0.28	!	5	IT05	-4.24	0.14	-1.03	0.78	1.29	0.42	1.12	0.42
16	IT16	5.28	1.09	1.13	0.28	!	16	IT16	5.28	1.13	0.28	!	14	IT14	4.44	0.25	-1.26	1.04	1.57	0.57	1.13	0.24
17	IT17	5.28	1.09	1.13	0.28	!	17	IT17	5.28	1.13	0.28	!	10	IT10	-1.48	0.19	0.14	1.19	1.41	0.34	0.91	0.57
	MEAN	0.00		1.10	0.22												-0.91	0.22	1.05	0.55		
	S.D.	4.18		0.08	0.77												0.61	0.77	0.29	0.25		

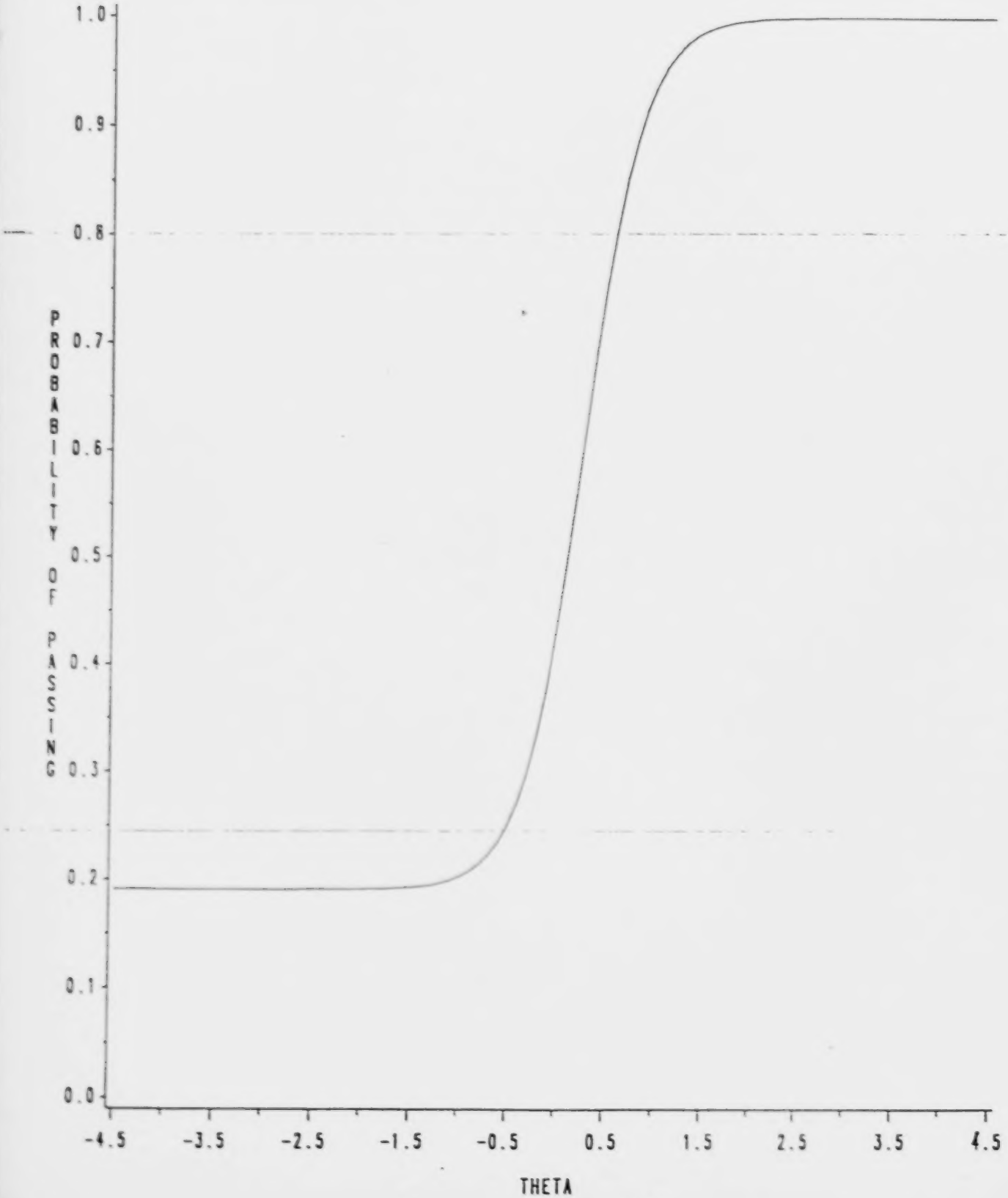
14 ITEMS CALIBRATED ON 32 PERSONS
32 MEASURABLE PERSONS WITH MEAN ABILITY = -0.06 AND STD. DEV. = 2.21

```
04 1.09 -4.85 0
05 1.11 -4.24 0
06 1.11 -4.24 0
07 1.07 -5.71 0
08 1.19 -2.88 0
09 1.13 -3.74 0
10 0.96 -1.48 0
11 1.06  1.51 0
12 0.96  3.01 0
13 1.21  2.35 0
14 1.09  4.44 0
15 1.07  5.28 0
16 1.07  5.28 0
17 1.07  5.28 0
```

```
*     THIS PROGRAM GENERATES ITEM CHARACTERISTIC CURVES;

CMS FILEDEF RAW1 DISK ICC RAWDATA A;

**************** DIVICE DRIVER BLOCK ********************;

*            DEVICE DRIVER FOR THE IBM-PC;

* GOPTIONS    DEVICE=TEK4014
              GPROTOCOL=GSAS7171;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
            THIS WILL PRODUCE A SCRIPT FILE;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=APA3820
              GDDMTOKEN=IMG240;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
   THIS WILL PRODUCE A BASIC SAS GRAPH -- FULL MARGINS;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=PRIM3820
              GDDMTOKEN=IMG240;

*************************************************************;
GOPTIONS COLORS=(BLACK RED GREEN BLUE)
         NOTEXT82;

DATA ONE; INFILE RAW1;
INPUT ITEMNO A B C;
**************** SIMULATING EXAMINEE THETAS FROM -4.0 TO +4.0 **********;
DO THETA=-4.0 TO 4.0 BY .1;
   PSI=C+((1-C)/(1+(EXP(-1.7*A*(THETA-B)))));
   OUTPUT;
END;
PROC SORT;
   BY ITEMNO;
**************** END OF DATA MANIPULATION ******************************;
PROC GPLOT;
   PLOT PSI*THETA/
                  NOLEGEND
                  VAXIS=0 TO 1.0 BY .10
                  HAXIS=-4.0 TO 4.0 BY 1
                  HM=0;
   BY ITEMNO;
SYMBOL1 C=RED I=L1 L=1;
TITLE1  C=YELLOW F=DUPLEX H=1 'ITEM CHARACTERISTIC CURVE';
LABEL THETA='ABILITY SCALE'
      PSI='PROBABILITY OF PASSING';
```

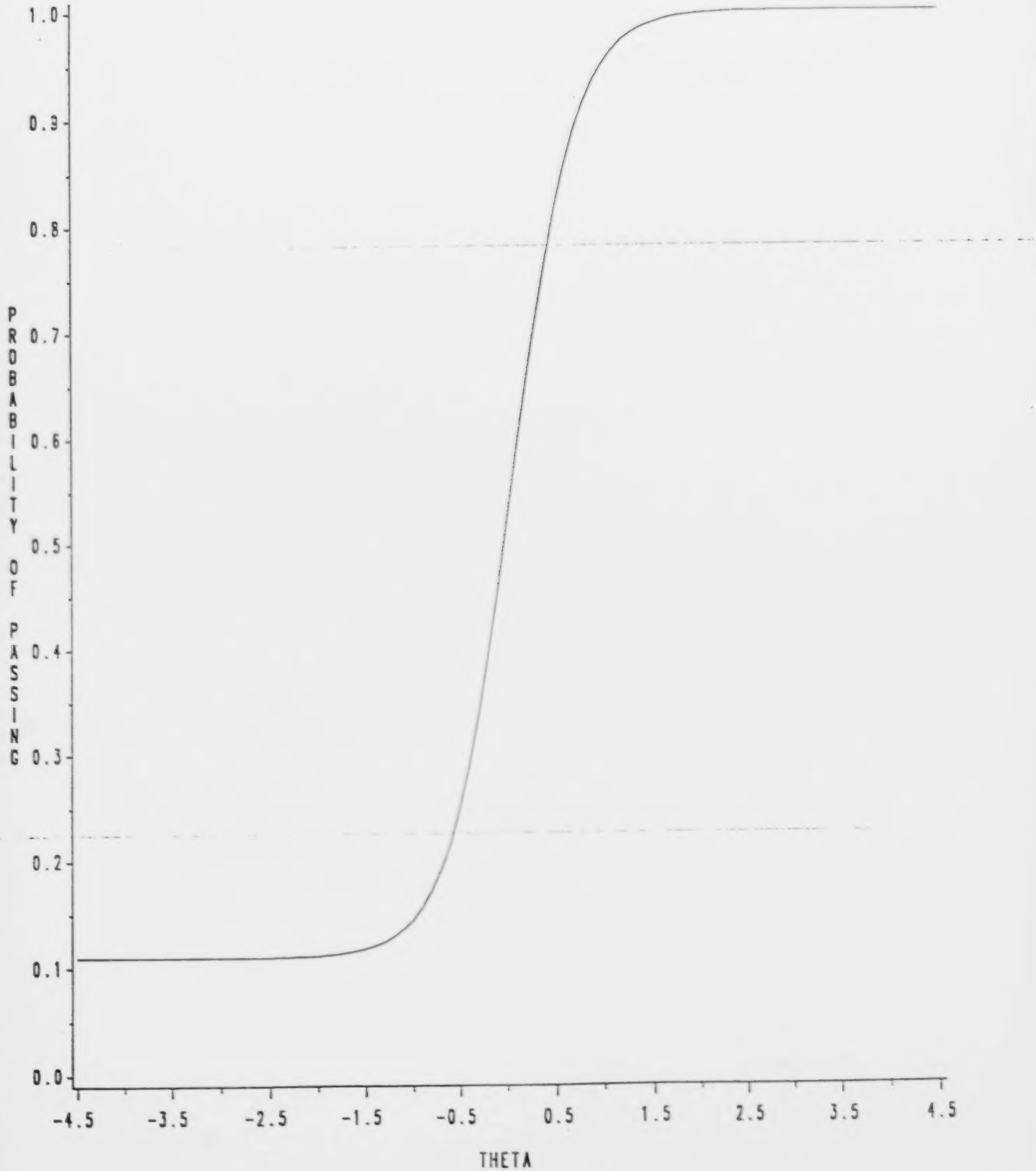
ITEM CHARACTERISTIC CURVE

ITEMNO=3



ITEM CHARACTERISTIC CURVE

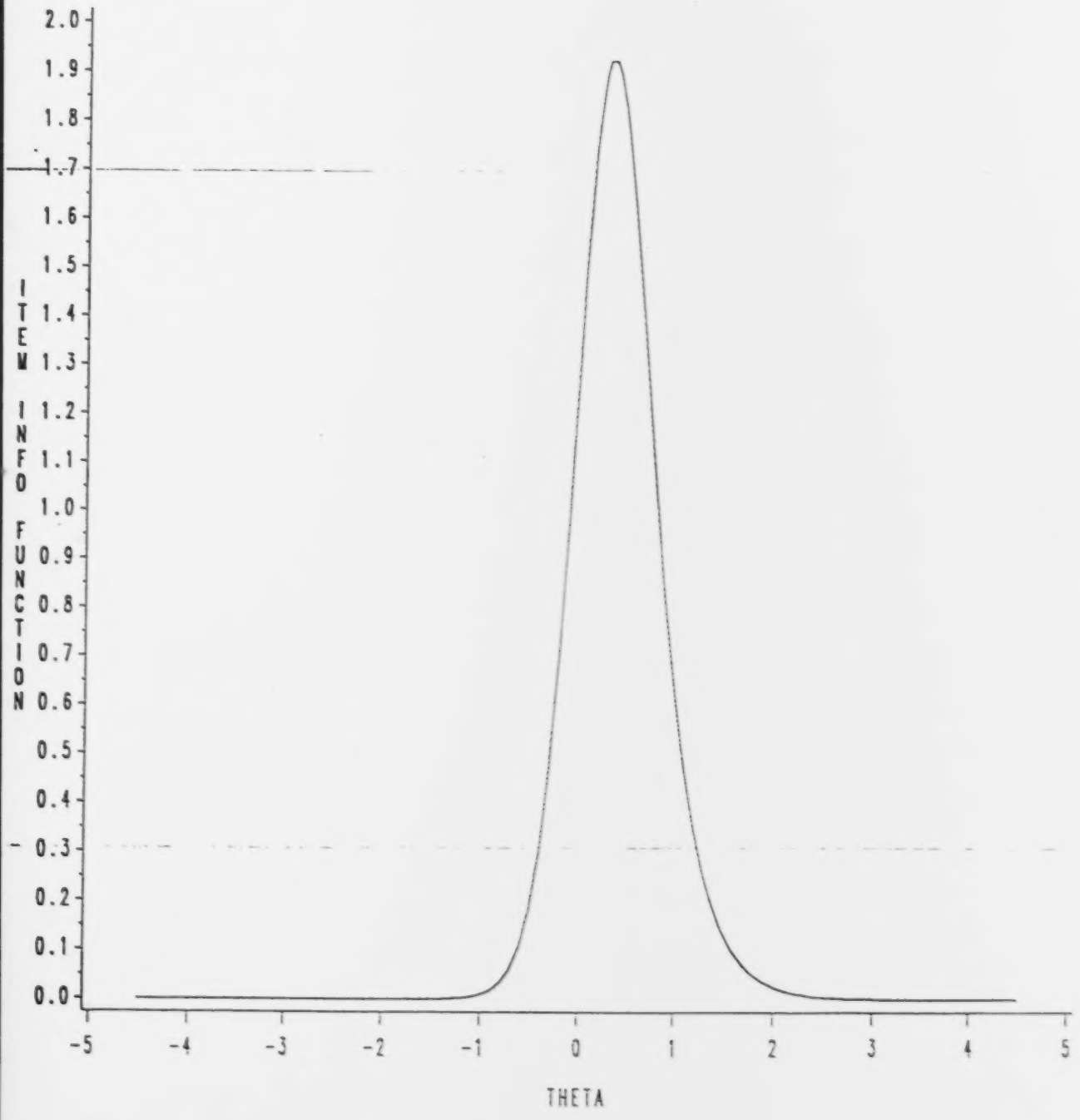
ITEMNO=4



```
*     THIS PROGRAM GENERATES ITEM INFORMATION FUNCTIONS;

CMS FILEDEF RAW1 DISK ICC RAWDATA A;

*************** DIVICE DRIVER BLOCK **********************;

*            DEVICE DRIVER FOR THE IBM-PC;

* GOPTIONS    DEVICE=TEK4014
              GPROTOCOL=GSAS7171;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
            THIS WILL PRODUCE A SCRIPT FILE;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=APA3820
              GDDMTOKEN=IMG240;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
    THIS WILL PRODUCE A BASIC SAS GRAPH -- FULL MARGINS;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=PRIM3820
              GDDMTOKEN=IMG240;

*************************************************************;
GOPTIONS COLORS=(BLACK RED GREEN BLUE)
         NOTEXT82;

DATA ONE; INFILE RAW1;
INPUT ITEMNO A B C;
*************** SIMULATING EXAMINEE THETAS FROM -4.0 TO +4.0 **********;
DO THETA=-4.0 TO 4.0 BY .1;
   TOP=((1.7*A)**2)*(1-C);
   BOT=(C+EXP(1.7*A*(THETA-B)))*(1+EXP(-1.7*A*(THETA-B)))**2;
   INFO=TOP/BOT;
   OUTPUT;
END;
DROP TOP BOT;
PROC SORT;
   BY ITEMNO;
******************** END OF DATA MANIPULATION ***************************;
PROC GPLOT;
   PLOT INFO*THETA/
                  NOLEGEND
                  HAXIS=-4.0 TO 4.0 BY 1
                  HM=0;
   BY ITEMNO;
SYMBOL1 C=GREEN I=SPLINE V=NONE;
TITLE1 H=1 F=SIMPLEX C=GREEN 'ITEM INFORMATION FUNCTION';
LABEL THETA='ABILITY SCORE'
      INFO='INFORMATION';
```

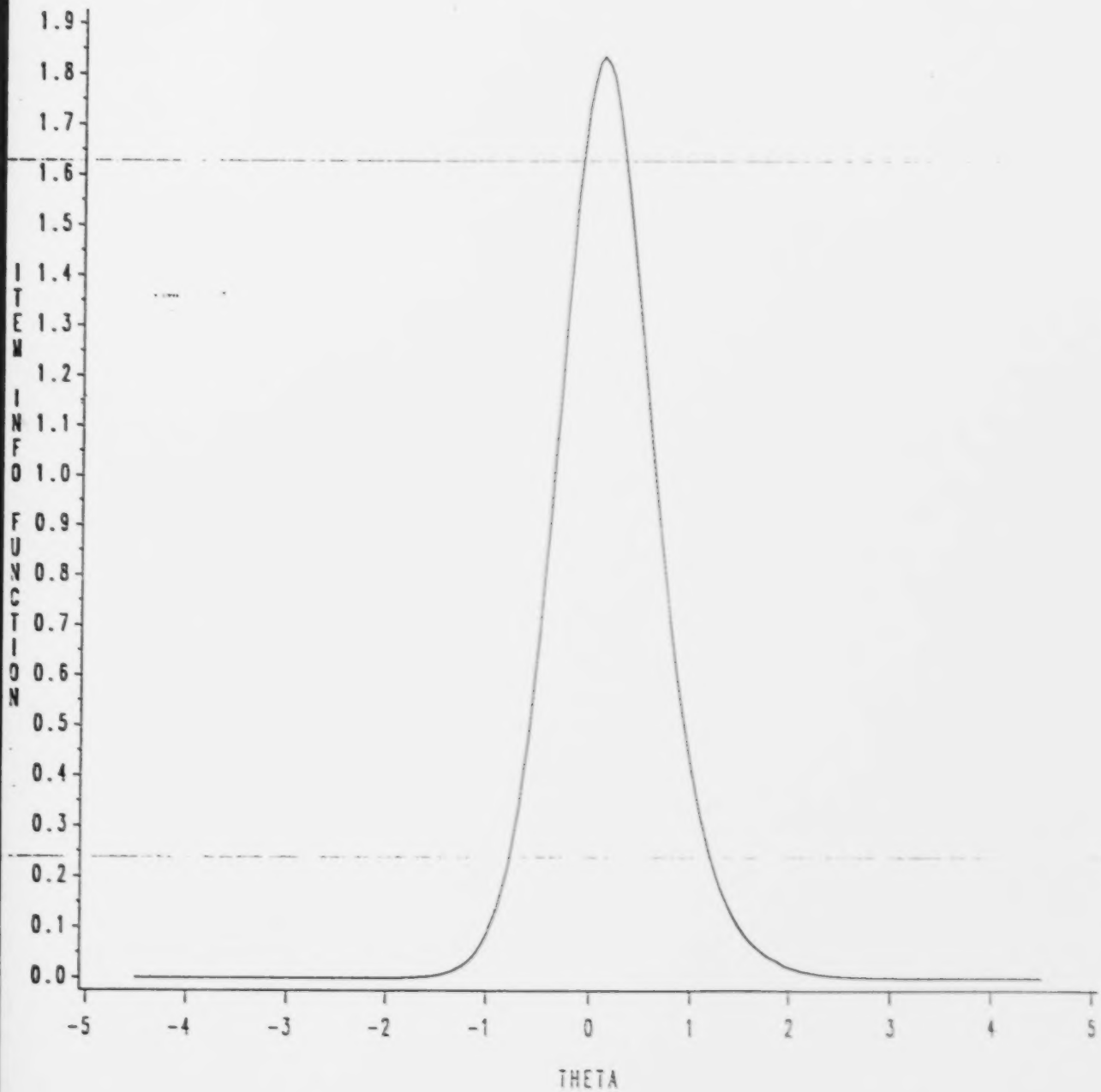
ITEM INFORMATION FUNCTION

ITEMNO=3



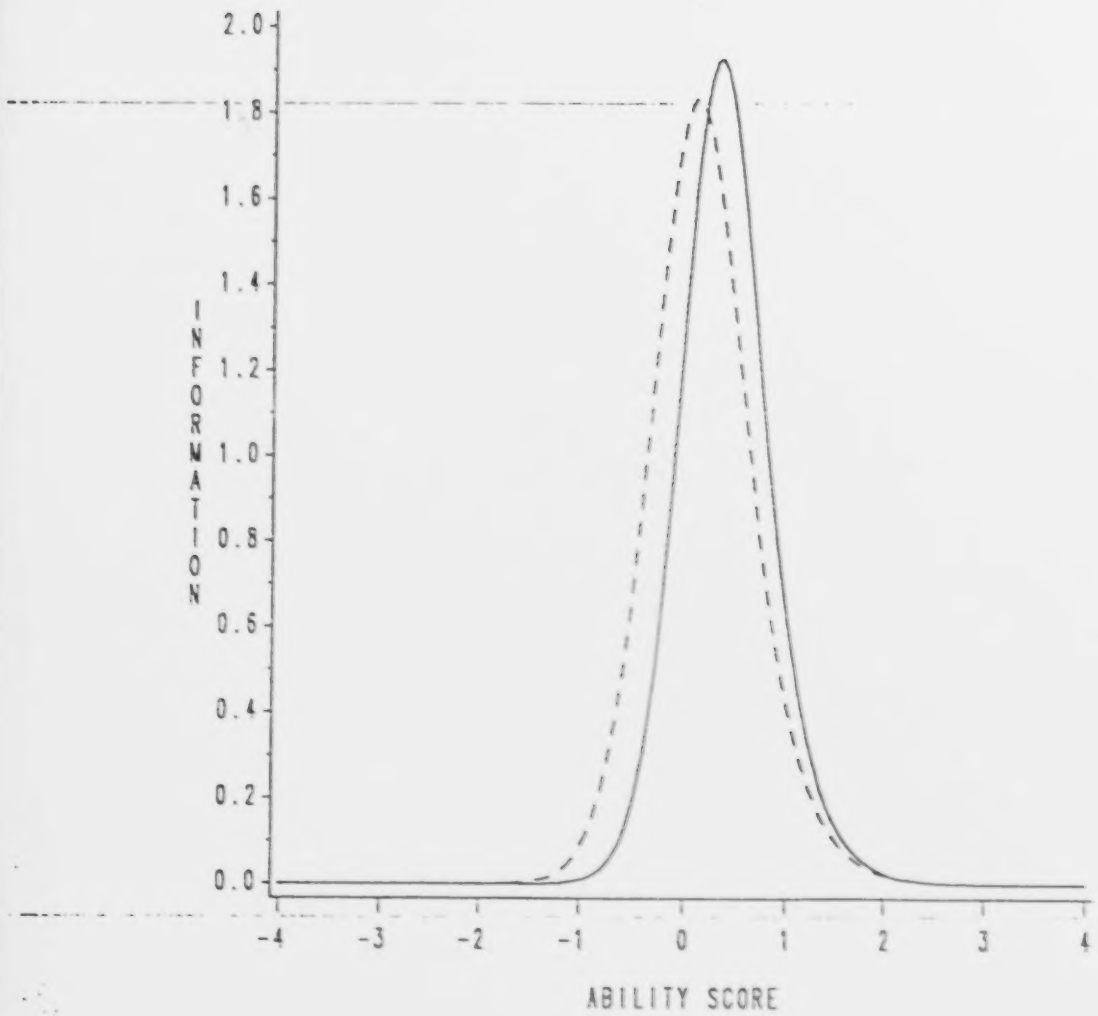
ITEM INFORMATION FUNCTION

ITEMNO=4



```
*     THIS PROGRAM GENERATES ITEM INFORMATION FUNCTIONS;

CMS FILEDEF RAM1 DISK ICC RAMDATA A;

**************** DIVICE DRIVER BLOCK ********************;

*            DEVICE DRIVER FOR THE IBM-PC;

* GOPTIONS    DEVICE=TEK4014
              GPROTOCOL=GSAS7171;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
            THIS WILL PRODUCE A SCRIPT FILE;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=APA3820
              GDDMTOKEN=IMG240;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
   THIS WILL PRODUCE A BASIC SAS GRAPH -- FULL MARGINS;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=PRIM3820
              GDDMTOKEN=IMG240;

*************************************************************;
GOPTIONS COLORS=(BLACK RED GREEN BLUE)
         NOTEXT82;

DATA ONE; INFILE RAM1;
INPUT ITEMNO A B C;
**************** SIMULATING EXAMINEE THETAS FROM -4.0 TO +4.0 **********;
DO THETA=-4.0 TO 4.0 BY .1;
   TOP=((1.7*A)**2)*(1-C);
   BOT=(C+EXP(1.7*A*(THETA-B)))*(1+EXP(-1.7*A*(THETA-B)))**2;
   INFO=TOP/BOT;
   OUTPUT;
END;
DROP TOP BOT;
PROC SORT;
   BY ITEMNO;

DATA TWO; SET ONE;
IF ITEMNO<3 OR ITEMNO>4 THEN DELETE;
******************** END OF DATA MANIPULATION ************************;
PROC GPLOT;
   PLOT INFO*THETA=ITEMNO/
                   HAXIS=-4.0 TO 4.0 BY 1
                   HM=0;
SYMBOL1 C=GREEN I=SPLINE V=NONE L=1;
SYMBOL2 C=GREEN I=SPLINE V=NONE L=20;
TITLE1 H=1 F=SIMPLEX C=GREEN 'ITEM INFORMATION FUNCTION';
LABEL THETA='ABILITY SCORE'
      INFO='INFORMATION';
```

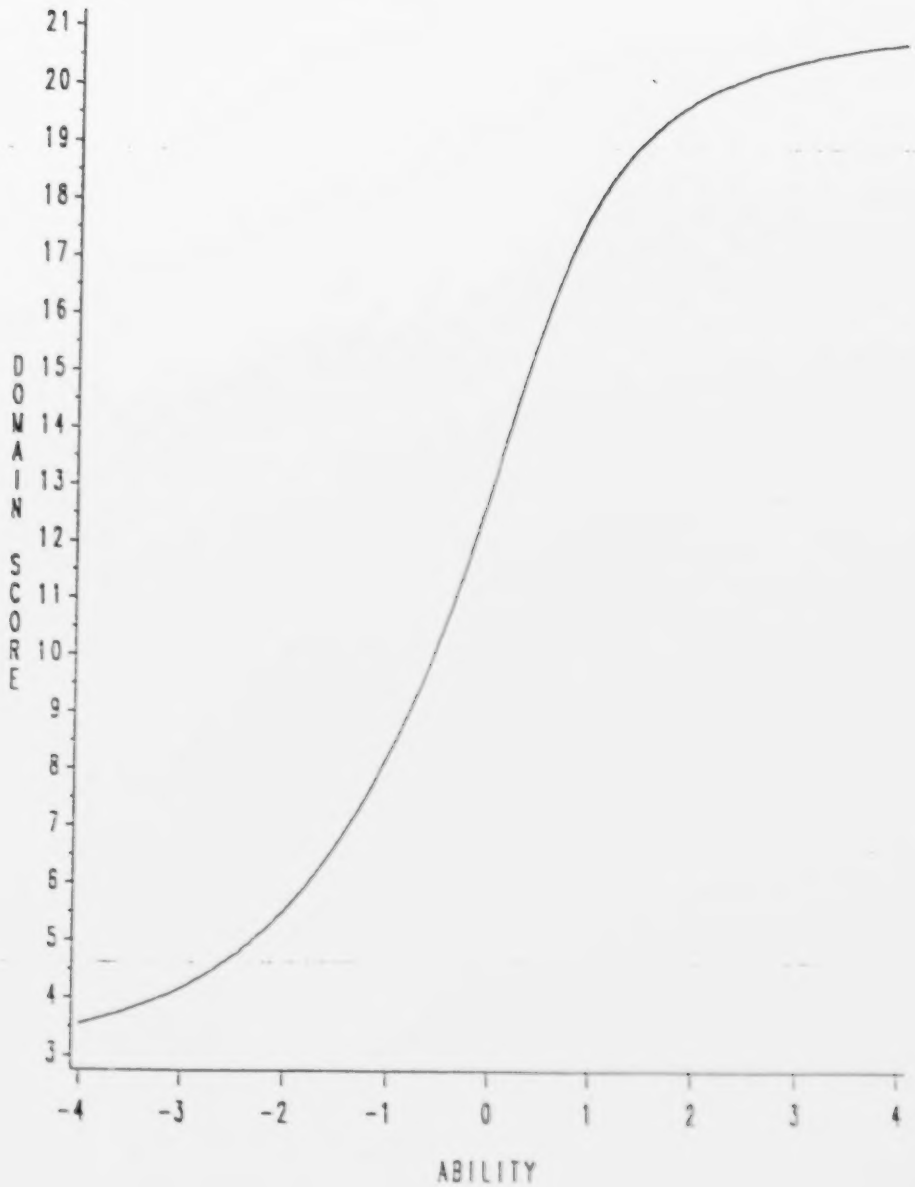
ITEM INFORMATION FUNCTION



ITEMNO —— 3 - - - 4

```
*    THIS PROGRAM GENERATES A TEST CHARACTERISTIC CURVE;

CMS FILEDEF RAM1 DISK ICC RAMDATA A;

*************** DIVICE DRIVER BLOCK ********************;

*            DEVICE DRIVER FOR THE IBM-PC;

* GOPTIONS    DEVICE=TEK4014
              GPROTOCOL=GSAS7171;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
            THIS WILL PRODUCE A SCRIPT FILE;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=APA3820
              GDDMTOKEN=IMG240;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
   THIS WILL PRODUCE A BASIC SAS GRAPH -- FULL MARGINS;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=PRIM3820
              GDDMTOKEN=IMG240;

*************************************************************;
GOPTIONS COLORS=(BLACK RED GREEN BLUE)
         NOTEXT82;

DATA ONE; INFILE RAM1;
INPUT ITEMNO A B C;
************** SIMULATING EXAMINEE THETAS FROM -4.0 TO +4.0 **********;
DO THETA=-4.0 TO 4.0 BY .1;
   PSI=C+((1-C)/(1+(EXP(-1.7*A*(THETA-B)))));
   OUTPUT;
END;
PROC SORT;
   BY THETA;
PROC MEANS NOPRINT;
   VAR PSI;
   OUTPUT OUT=STATS SUM=SUM;
   BY THETA;
************** END OF DATA MANIPULATION ******************************;
PROC GPLOT DATA=STATS;
   PLOT SUM*THETA/
                  NOLEGEND
                  HAXIS=-4.0 TO 4.0 BY 1
                  HM=0;
SYMBOL1 C=GREEN I=SPLINE V=NONE;
TITLE1 H=1 F=SIMPLEX C=GREEN 'TEST CHARACTERISTIC CURVE';
LABEL SUM='DOMAIN SCORE'
      THETA='ABILITY';
******************** END OF PLOTTING ***********************************;
PROC PRINT DATA=STATS;
```

TEST CHARACTERISTIC CURVE



```
*       THIS PROGRAM GENERATES A TEST INFORMATION CURVE;

CMS FILEDEF RAW1 DISK ICC RAWDATA A;

**************** DIVICE DRIVER BLOCK **********************;

*             DEVICE DRIVER FOR THE IBM-PC;

* GOPTIONS    DEVICE=TEK4014
              GPROTOCOL=GSAS7171;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
            THIS WILL PRODUCE A SCRIPT FILE;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=APA3820
              GDDMTOKEN=IMG240;

*       DEVICE DRIVER FOR THE IBM3280 LASER PRINTER
    THIS WILL PRODUCE A BASIC SAS GRAPH -- FULL MARGINS;

* GOPTIONS    DEVICE=GDDMFAM4
              GDDMNICKNAME=PRIM3820
              GDDMTOKEN=IMG240;

*************************************************************;
GOPTIONS COLORS=(BLACK RED GREEN BLUE)
         NOTEXT82;

DATA ONE; INFILE RAW1;
INPUT ITEMNO A B C;
************ SIMULATING EXAMINEE THETAS FROM -4.0 TO +4.0 *************;
DO THETA=-4.0 TO 4.0 BY .1;
   TOP=((1.7*A)**2)*(1-C);
   BOT=(C+EXP(1.7*A*(THETA-B)))*(1+EXP(-1.7*A*(THETA-B)))**2;
   INFO=TOP/BOT;
   OUTPUT;
END;
DROP TOP BOT;
PROC SORT;
   BY THETA;
PROC MEANS NOPRINT;
   VAR INFO;
   OUTPUT OUT=STATS SUM=SUM;
   BY THETA;
******************** END OF DATA MANIPULATION ***************************;
PROC GPLOT DATA=STATS;
   PLOT SUM*THETA/
                  NM=0
                  NOLEGEND
                  HAXIS=-4.0 TO 4.0 BY 1;
SYMBOL1 C=GREEN I=SPLINE V=NONE;
TITLE1 H=1 F=SIMPLEX C=GREEN 'TEST INFORMATION CURVE';
LABEL THETA='ABILITY SCALE'
      SUM='TEST INFORMATION';
********************** END OF PLOTTING ********************************;
PROC PRINT DATA=STATS;
```

TEST INFORMATION CURVE